

The Effect of a Reverse Fault on Microcrack and Permeability Anisotropy in Granite, Tono Area, Central Japan

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Brittle deformation in granite generates fracture systems with different patterns. In fault zones, fracture connectivity is perhaps the most important factor that controls fluid permeability. To understand the relationship between deformation and permeability in granite affected by a high-angle reverse fault, we performed fracture analysis and permeability measurements in drill core samples from the Toki Granite in Gifu Prefecture, Central Japan.

Detailed fracture analyses at both macroscopic and microscopic scales, together with characterization of drill-core physical properties, are performed in four different domains in the granite: (1) undeformed granite, (2) fractured granite with cataclastic seams, (3) fractured granite from the damage zone, and (4) foliated cataclasite from the core of the fault.

Intact samples of these four domains, taken from horizontal and vertical orientations, show developing fracture anisotropy toward the fault, especially in the damage zone. Microstructural observations suggest that fragmentation of crystals results in grain-size reduction within the fault zone and anisotropy in microcrack development within the damage zone. Bulk porosity varies from 0.54% for unaltered fresh granite to over 5.4% for foliated cataclasite from the central part of the fault zone. The confocal laser scanning microscopy (CLSM) technique is applied to visualize the fracture anisotropy developed in resin-impregnated samples. Microcracks under CLSM were mainly observed along grain boundaries, mineral cleavage, and intragranular fractures. CLSM allows visualization of network-type microcracks in horizontal sections and elongated open-type microcracks in vertical sections.

Permeability measurements were performed using the pore oscillation technique with nitrogen gas as a pore fluid. Confining pressure varied from 25 to 200 MPa with,

pore pressure kept around 20 MPa. High permeability values were obtained in horizontal sections along network microcracks, values that were one to two orders of magnitude higher than for vertical sections. The findings suggest that network microcracks in the horizontal sections enhance permeability by means of higher connectivity and lower sensitivity to effective confining pressure.